Renewable and Sustainable Energy Reviews 35 (2014) 126–135

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

The development of policy instruments in supporting low-carbon governance in China

Nannan Wang [a,1], Yen-Chiang Chang [b,*]

[a] School of Management, Shandong University, No. 27 Shan Da Nan Road, Jinan, Shandong 250100, China
[b] School of Law, Shandong University, No. 5 Hong Jia Lou, Jinan, Shandong 250100, China

ARTICLE INFO

Article history:
Received 21 October 2012
Received in revised form
23 December 2013
Accepted 7 March 2014
Available online 17 April 2014

Keywords:
Policy instruments
Low-carbon development
Low-carbon governance
Chinese perspective

ABSTRACT

This paper examines the development of policy instruments that support the low-carbon governance in China. The instruments are analysed in five aspects in relation to the key policies in low-carbon governance in China, including: energy conservation, developing new energy, reforestry, developing circular economy, and industry restructuring. Each aspect is discussed in three instrument groups which are (1) law and regulations, (2) industry standard and (3) finance and taxation. This research suggests that law enforcement for the new established laws should be further strengthened and stricter supervision systems should be in place to safeguard effective implementation of low carbon policies, measures and standards, especially for those energy condensed sectors. More rigorous industry standards regarding energy efficiency should be considered to help eliminate outdated equipments in industries and promote the introduction of more climate-friendly technologies. The industrial standards should be given strong legal support in accountability, in order to enforce their complete application once in operation. New policies and instruments need to be introduced in order to reduce carbon print by landfill. The backward law and industrial standards in China should be upgraded more regularly, therefore to support the low carbon development strategy.

Contents

* Corresponding author.
E-mail addresses: southsouth@hotmail.co.uk (N. Wang), Naluisle@aliyun.com (Y.-C. Chang).
[1] Tel.: +8618764178309.

http://dx.doi.org/10.1016/j.rser.2014.03.021

1. Introduction

As the world largest manufacturer, China's rapid economic development over the past two decades has caused serious environmental damage. The energy consumption in China in year 2010 was five times more than the consumption in 1980 [1], while the economic reform started in China. The composition of the main energy resources is shown in Fig. 1, where the renewable energy accounts for 8.8% of the total energy production in China in 2011, to which was only 3.8% in 1980 [1]. The energy production in China relies heavily on coal, which has consistently remained over 70% of total energy produced in China since the 1980s.

In response to the United Nations Framework Convention on Climate Change (UNFCCC), the Chinese Government formulated the China's National Climate Change Programme (2007), setting up an overall target of a 20% reduction on energy consumption per unit of GDP, where the principles and key actions were also suggested, as well as policies and measures to address climate change for the period until 2010. Furthermore, the Chinese government announced another target of cutting carbon emission per unit GDP by 40–45% in comparing to 2005 level. China's GDP per capita, however, is still below the world average. As economic development drives the improvement of social condition forward, it remains the prime goal of the Chinese Government. Even although China has become the biggest carbon emitter in the world, its carbon emission per capita are still below the world average [2]. There is a great potential for the overall carbon emission in China to grow in future development.

As many researchers estimated, the downturn of carbon emission is unlikely to happen in China in the short term [3–5]. For example, Wang and Watson [5] projected the carbon emission path of China to 2050 and concluded it is possible to slow down the emission growth and reduce it from 2020. The critical area requiring significant improvement is the energy efficiency of the key industries, such as construction and transportation. Wang et al. raised the concern on the nuclear power policy in China [6].

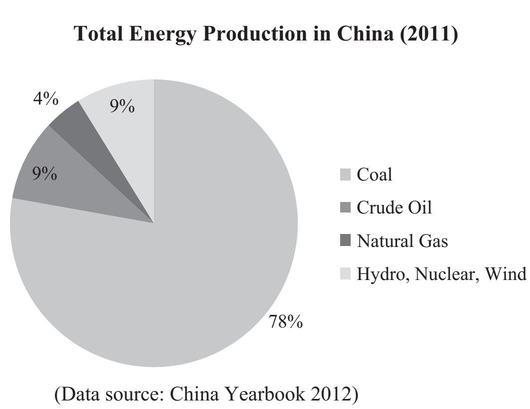


Fig. 1. The energy production in China as in 2011..
Data source: China Yearbook 2012

Although China faces various challenges on the way towards low-carbon economy, the government established ambitious low-carbon targets showing determination in combating climate change. The Chinese Government paid greater attention to low-carbon development in recent years. In 2011, the State Council issued the Decision on Strengthening Energy Conservation and Carbon Reduction Work Programme in the 12th Five-Year Plan. This work programme specified the main policies regarding low-carbon development in the future, including: (1) strengthening accountability on low-carbon targets, (2) industrial restructuring, (3) implementing energy saving projects, (4) development of circular economy, (5) promoting energy efficient technology, (6) improving financial instruments for low-carbon development, (7) strengthening supervision system, (8) establishing market-oriented mechanism for energy saving and carbon reduction, (9) improving national standards, and (10) mobilising involvement of society. There were a large number of new laws and regulations introduced by the government targeting low-carbon development [7].

The accomplishment of targets, however, requires not only strong determination but also effective policy instruments that can support low-carbon development strategy. This research shed a light on the examination of the development of the policy instruments regarding low-carbon development targets that recently announced by the Chinese government.

2. Studies on low-carbon Policies in China

There are many researches contributing to low-carbon economy, policies and governance at different governmental levels. The issues include innovation towards low carbon economy [8], the transition to low-carbon economy [9], pathway to low-carbon economy [10]. McEvoy et al. evaluate the prospect for increased employment and low-carbon economy [11]. Price et al. provide indicator for low carbon economy on province and city level [12]. There is other research also focused on local level, for example the discussion of low-carbon energy policies at solely the provincial level in China [6]. Wang et al. [13] presented a framework for low-carbon governance in three levels: strategy, methodology and operation. They stated that the legal instrument was a powerful tool for the government to perform good low-carbon governance.

The low-carbon development policies of the Chinese Government also receive interests from researchers. Many research focus on curtain aspect of low-carbon energy policies in China, such as energy efficiency policies [14,15], renewable energy policies [16–18], circular economy strategy [16]. Jiang et al. state that the law, statues, management institutions and public education should be enhanced in China for a low-carbon economy [19]. Similarly, Wang et al. suggest the government should strengthen law enforcement, industry standards and education [13].

Some research focused only one aspect of low-carbon policies in China, for example Yuan et al. discuss energy saving issue of energy policies in China [20]. Wang et al. analyse the effectiveness of the new energy conservation regulation in China [21]. Andrews-Speed

Table 1
Previous research on low-carbon related policies in China.

Research problems	References
Carbon emission prediction	Chen [3], Cai and Wang [4], and Wang and Watson [5]
Emission control	Chang and Wang [7]
Low-carbon policies at province level	Wang et al. [6] and Price et al. [12]
Government management	Li [8,32], Chang and Wang [7] and Qi [37]
Development strategy	Luchsinger [10], Wang et al. [6,13], Jiang et al. [19] and Zhang [29]
Energy efficiency policy	Zhou et al. [14], Yuan et al. [20], Andrews-Speed [22], Lo [15] and Fang and Zeng [26]
Renewable energy policy	Lo [15], Zeng et al. [17] and Zhang and He [18]
Circular economy	Li et al. [16] and Sun and Li [23]
Law and regulations	Li [8,32] and Wang et al. [21]
Industry regulations	Wang et al. [21] and Yoshino et al. [31]
Reforestration	Huang et al. [25]
Impact of low-carbon policies	McEvoy et al. [11], Fang and Zeng [26] and Zhang et al. [28]
Low-carbon evaluation system	Price et al. [12] and Wang et al. [6,13]

assesses the drive for the energy efficiency in China [22]. Sun and Li review the policies related to waste landfill problem in China [23]. Chai and Zhang discuss the technologies and policies contribute to the transition of China to a sustainable energy system [24]. The estimate of Huang et al. reveals a close relationship between forestation and carbon sequestration [25]. Therefore, some management instrument are suggested in literature for the Chinese government, including energy saving, optimisation of energy structure, law enforcement, promulgation of standards, technologies innovation, adoption of renewable portfolio system, education [26–28]. China needs to act as a responsible developing country to set a good example for developing countries [29]. Many believed that China can be a good partner in fighting global climate change [13,29].

The previous studies regarding low-carbon policies in China focus on various aspects as shown in Table 1. Currently there is a lack of a structured review on the development of the policy instruments system which supports the low-carbon development targets in China.

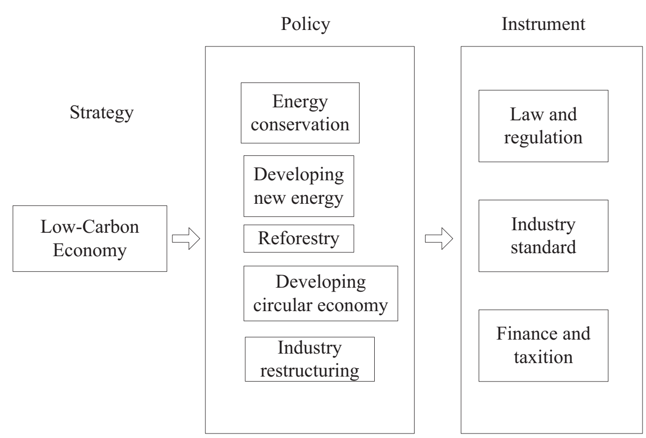


Fig. 2. The low-carbon strategy, policy and instruments.

3. Research methodologies

The policies and instruments regarding low-carbon development was broken down into three levels as shown in Fig. 2. On the basis of literature review, the strategy of low-carbon development in China was related to five aspects of policies. The regulatory performance is affected by legal mandate [30], which also defines industry standards. The tax and finance policies are also determined by legal system. For each of five policy aspect, the policy instruments were discussed in three groups including law and regulations, industry standard and finance and taxation.

The development plans, policies, law and taxation system are controlled by the central government, acting as a strategic guideline for the industry and local government [10]. It can be summarised from the development plans and key government documents that the key policies supporting low-carbon development include: (1) developing new energy, (2) improving energy efficiency, (3) reforestry, (4) developing circular economy, and (5) industry restructuring. This paper intends to review the development of the policy instruments to support the above stated policies and provide suggestions for the future development. Data collection methods involved in this research include document review, internet survey and literature review, and interview survey. There were 10 senior experts and professionals from energy, industry and public sectors joint the unstructured interview survey.

When appropriate, comparison is made between the practice of China and other countries in order to find problems and make suggestions for improvement in low-carbon governance in China.

4. The development of policy instruments

4.1. Energy conservation

4.1.1. Law and regulations

The first environmental law in China was the Law on Environmental Protection of the People's Republic of China (PRC) (1979). For a long period, the government paid great efforts on economic development. Until recently, there were several key laws and regulations specifically addressing energy saving issued by the Chinese Government. Following the 1997 Kyoto Protocol, the Energy Conservation Law of the PRC came into force in 1998 (amended in 2007). This law was formulated for the purpose of promoting energy conservation and increasing energy efficiency. The law covered energy conservation administration, rational energy utilisation, technology progress in energy conservation and the corresponding legal liabilities. The responsibilities and power of the central government and the local governments were defined on energy conservation of construction, transportation, public institutions, and key energy-using units. The Law of the PRC on Promoting Clean Production (2002) was enacted to promote cleaner production, increase in the utilisation ratio of resources, reduce and prevent pollutant-generation, and promote the sustainable development of the economy and society.

In 2004, energy conservation was addressed as a national policy in the 11th Five-Year Plan (for the period 2005–2010). The legal system has experienced steady progress in environmental protection and carbon reduction in recent years.

The Comprehensive Work Scheme on Energy Conservation (2007) adopted a series of institutional, legal, economic and

technological instruments in order to (1) strengthen and control the scale of energy-intensive and pollution-intensive industries, (2) phase out backward and energy intensive productions and equipment, (3) adjust and optimise energy mix, and (4) emphasise the administration of key units' energy saving. The enforcement of the Energy Conservation Law of the PRC also presented a good reflection of the afore stated policy.

The legal system covered environmental protection and energy conservations in various aspects. A large number of regulations were introduced to various industry sectors such as: energy, building, manufacturing, transportation, recycling and renewable technologies. For example, the State Council issued the Civil Building Energy Conservation Ordinance, aiming to target low energy efficiency problems of civil buildings in 2008. Other regulations followed the energy conservation law included the Power Conservation Management Method (2000), the Energy-efficiency Label Management Method (2004), Energy Conservation Regulation for State-funded Institutions (2008), and Road Transport Vehicle Fuel Consumption Monitoring and Supervision and Management Method (2009).

Notwithstanding the announcement of new laws supported the low-carbon governance strategy of the central government in China, the old sectoral energy law appeared backward. The Coal Law issued on 1996 and the Electricity Law in 1997 had not included any specific articles on energy saving and emission reduction [10]. For example, the Coal Law of the PRC (1996) regulated the exploitation and protection of coal resources and the manufacture and transaction of coal products. The utilisation stage of coal product is excluded from the law.

The objectives of the Electricity Law of PRC are to protect and promote the development of power industry, to safeguard the legitimate rights and interests of the investors, operators and users and to secure safety during operation. Article 25 of the Electricity Law stated that there shall be only one power supplier within each electricity service area. The consequence of this law is the monopoly of state-owned corporate, such as the National Grid, in the power industry in China. Although the Energy Conservation Law encourages the development of new and renewable energy by the private sector, the Electricity Law derives the rights of new energy providers to supply electricity directly to the end users. Therefore, the question is how to connect the new energy on the National Grid. In this case, amendment is needed in order to avoid contradiction between the laws and eliminate obstacles of the development of new energy, including renewable energy and nuclear energy, in reality. The interviewees suggested the backward laws need to be upgraded in order to coordinate with the current policies of low-carbon development in China.

4.1.2. Industrial standards

The government introduced a dozen of initiatives to restructure key industries and sectors since 2006 [10], such as the Enforcement Regulations of the Ten Major Energy Savings Projects. In the main industries such as construction and the energy sectors, new standards related to energy efficiency and carbon reduction have been introduced recently which enabling the low-carbon strategies and methodologies to be practiced at the operational level.

Many developed countries firstly targeted one of the largest energy consumer – the building related sectors such as the UK, Germany and Japan [13]. In China the building industry has also adopted new design standards such as the Design Standards for Energy Efficiency of Residential Buildings in Severe Cold and Cold Zone (JGJ26-2010), Design Standards for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone (JGJ134-2001) (2001), Design Standards for Energy Efficiency of Residential Building in Hot Summer and Warm Winter Zone (JGJ75-2003), Standards for Energy Efficiency Test of Residential Building (JGJ/T 132-2009), Standards for Energy Efficiency Test of Public Building (JGJ/T177-2009), Technical Code for the Retrofitting of Public Building on Energy Efficiency (JGJ176-2009) (2009), Design Code for Green Residential Building (JGJ/T229-2010) and Technical Specification for Energy Conservation Renovation of Existing Heating Residential Building (JGJ129-2001). However, the design standards were found to be less strict in energy conservation in comparison with the equivalent standards in some western countries. For example, Wang et al.'s [21] research compared the energy efficiency of the Regulations on Energy Conservation for Public Institutions (GB50189-2005) regulation to the UK Part L regulation and discovered that a building built under the GB50189-2005 needed 29% more energy than the building that fulfils the Part L Building Regulations. Yoshino et al.'s [31] also found that the modern buildings were poorly insulated and the energy efficiency could be significantly increased across China.

Some practitioners such as project managers and design engineers were invited to take part in an interview survey. Their views on the execution of new industrial standards were collected for analysis. We found that the biggest issue at the operational level of low-carbon governance in China is the poor enforcement of these standards. The entry standards of small-sized construction market are relatively low in comparison to large projects, causing high competitions and low margin. As there is currently no official measure on the overall energy performance of built assets in China, quality control become important to ensure the energy efficiency of the buildings consistent with their designed level. However, the projects are often wrongly budged with under-market price, which result in poor supervision and quality control.

Unlike some developed countries, the industrial standards in China are not set out by law. As a result the industrial standards are not completely implemented in practice. The main reason is that these industrial standards are not legally binding, for only some of the articles in these building standards are mandatory provisions. The enforcement of the standards in the building industry is so weak that 80% of new buildings in China still exhibit poor energy efficiency [32]. Although energy saving has been included in the development strategy of the government, the industrial standards are still less strict which hinder the development of China towards a low-carbon economy. The survey of the United Nations also showed many of the current industries standards in China were out of date [10].

The National Standards Commission issued the national standards entitled General Principles of Stipulation of Energy Conservation Standards System for Enterprise (GB/T22336-2008), which showed and provided the principles and requirements to guide the enterprises formulating their own energy conservation standards system.

In the transportation sector, the government launched the low-carbon transportation action. The first national compulsory standard to control the fuel consumption limit: Fuel Consumption Limits For Passenger Cars (GB 19578-2004) was issued in 2004. The ministry of Environmental Protection issued National Phase III Vehicle Emission Standards in 2007. Limits and Measurement Methods of Fuel Consumption for Commercial Vehicle for Passenger Transportation (JT711-2008), Operating Vehicle Fuel Consumption Limit and Measurement Method (JT719-2008) and Multiple Performance Requirement and Detecting Methods for Commercial Vehicles (GB18565-2001) have been employed to limit the development of energy inefficient vehicles, improve fuel efficiency in general and reduce the consumption of oil in particular.

In 2010, the Ministry of Industry and Information issued the Guidance for the Energy-saving and Emission-reduction of Iron and Steel Industry (2010) which requires the iron and steel

enterprises to reach the industrial standards, such as The Norm of Energy Consumption per Unit Product of Major Procedure of Crude Steel Manufacturing Process (GB21256-2007), The Norm of Energy Consumption per Unit Product of Coke (GB21342-2008) and The Norm of Energy Consumption per Unit Product of Ferroalloy (GB21341-2008). In order to explore the potential energy-saving capabilities of the iron and steel industry, The Development Policy for Iron and Steel Industry (2006) and Industrial Restructuring and Guiding Catalogue (2005) was issued to speed up the steps of the phasing out the outdated production capacity, and in accordance with the Development Policy for Iron and Steel Industry and Industrial Restructuring Catalogue to speed up the phasing out of the backward standards.

The industrial standards are the minimum requirement for the industry to reduce carbon emission during operation. In addition to the national standards, there are numerous energy efficiency evaluation tools adopted in developed countries, such as the energy conformity certificate in Germany, the energy labelling system in Denmark, the BREEAM assessment tool in the UK, the LEEDs system in the US, the CASBEE in Japan [13]. The implementation of these additional assessment tools have been encouraged by many government initiating in the government procurement projects. The UK government requires the Building School for Future school projects to fulfil the BREEAM assessment, whilst Green Procurement is another new requirement of government procurement management in the UK. The LEEDs assessment tool was also applied to the government procurement projects in the U.S. Some assessment tools and standards were also introduced in China, for example the Evaluation Standard for Green Buildings (2006), the Technical Guidelines for Green Buildings (2005) have been introduced in the biggest energy consumer – the construction industry [33]. However, these new assessment systems have not been required by government procurement projects in China, therefore, they were not widely applied in the industry.

For the residential appliance industry, the government introduced new standards and labelling systems. The main programmes include mandatory minimum efficiency standards, voluntary energy-efficiency labelling, and mandatory energy information labelling. Almost all large electronics products are covered by the voluntary labelling programme, but there are an increasing number of medium and small products to be included in the mandatory standards system [14].

4.1.3. Finance and taxation

In order to facilitate low-carbon development along with economic growth, the government introduced a series of financial and tax incentives during the timeframe of the 11th Five-Year Plan. The energy prices have strong relation with the industrial structure as the industrial electricity price in China is 18% lower than the world average [34]. The petrol price in China is even lower than that of the United States, let alone European Union and Japan [35]. The Detailed Rules for the Implementation of the Interim Regulations of the PRC Concerning Resource Tax (2008) and The Provisional Regulations of the PRC Concerning Resource Tax (2008) have caused slight rise of energy prices in China.

In respect of the reform of the energy price mechanism, the government adjusted the tax and fees of refined petro projects, increased the electricity price for energy intensive industries, and promoted the metered charging of heat supply to household.

The consumption tax for large, low energy-efficient vehicles was introduced by the Ministry of Finance (MOF) in the Revised Consumption Tax For Larger, Energy-Inefficient Vehicles in 2006. The export tax on high energy-consumption products was also adjusted in the Reduced Export Tax Rebates For Many Low-Value-Added But High Energy-Consuming Products in the same year. The Ministry of Finance also announced the interim management measures for incentives to energy saving technology reforms and phase out programme in 2010.

The Law of the PRC on Enterprise Income Tax (2007) and The Implementation Regulations of the Corporate Income Tax of the PRC (2007) stipulated exemption and reduction of tax and accelerated depreciation to energy conserving enterprises. However, unlike in some developed countries, in China the carbon tax has not been introduced to the current taxation system. The Notice of Income Tax for the Chinese Clean Development Mechanism Funds and the Implement Enterprises (2009) stated that enterprises implementing the Clean Development Mechanism (CDM) project were entitled to tax relief according to their reduction on green house gas (GHG) emission volume.

In the recent oil tax reform, the government regulated the oil price, and cancelled the road tolls according to The Notice of the State Council on the Oil Tax Reform, National Development and Reform Commission of the PRC (2009).

The government announced the Interim Measures of Financial Incentives Fund Management on Energy-saving Technological Transformation (2007), followed by a 7 billion RMB award to the corporation transforming energy-saving technologies. The government's special fund to support the energy-saving and emission-reduction increased from 235 billion RMB in 2007 to 495 billion RMB in 2009, which were mainly awarded to the ten key energy-saving projects in China every year. The National Development and Reform Commission (NDRC) issued the Implementation Measures of 10 Key Projects in 11th Five-Year Plan in 2006, intending to reduce energy use in industry and buildings.

In addition, energy saving has been integrated into both the short-term and long-term national development plans. The effectiveness of these recent strategies can only be reflected by the operations of the local government and the industrial sectors in practice. Since 2005, the NDRC and MOF have included energy efficient products in the government procurement programme. In order to improve the energy efficiency for existing residential buildings in northern China, the government introduced incentive funds for heating metering transform programme in the Interim administrative method for incentive funds for heating metering and Energy efficiency retrofit for existing residential buildings in China's northern heating area in 2007.

4.2. Development of new energy

4.2.1. Law and regulations

The policy to develop new energy was first found in the 1996–2010 Outline of New and Renewable Energy. The Renewable Energy Law of the PRC took effect in 2005, in which urbanisation and renewable energy have been listed as the nation's preferential areas for the future development. The law regulated the development and utilisation of renewable energies during urban development, and specified the responsibilities of the energy, construction, agriculture industries towards low-carbon development. The main purpose of the law was to promote the development of renewable energies.

The Renewable Energy Law was amended in 2010 in order to introduce new provisions to promote the utilisation of renewable energies and to solve the transmission problem of the renewable energies into the national power grids. Therefore, the renewable energy was given a more important status of a new contributing area to the economic growth, rather than a simple energy solution in the previous version. According to the law, the newly established Renewable Energy Fund would be used in much wider aspects in respect of renewable energy development. Consequently new measures were issued by the central government to manage the various financial supports to new energy development.

4.2.2. Industrial standards

The Index System for Cleaner Production Assessment of Coal-fired Power Industry (2007) and The Norm of Energy Consumption per Unit Product Coal-fired Power Set (GB21258-2007) were issued for the electricity industry to eliminate the small-scale backward units and promote the generation of clean power.

In order to regulate the emerging renewable industry, the government released several industrial standards. The Entry Standards for Wind Power Equipment Companies (Exposure Draft, 2010) increased the market entry threshold of this type of companies. In 2011 the National Energy Administration issued three standards to regulate wind power industry, which were the Standard Construction Regulation for Wind Power, the Charter of the Wind Energy Industry Standardisation Technical Committee, and the Framework for Wind Power Industry Standardisation. In the same year, the Entry Condition of the Poly-silicon Industry was also announced by the government, which increased the entering threshold of the poly-silicon industry. Those standards intended to solve the problem of the lack of industry standard and regulating the companies in the fast growing renewable industry. It was estimated that the renewable energy companies with low productivity and efficiency will be opt out from the market following the standards. However, the effectiveness of the standards remains to be seen.

4.2.3. Finance and taxation

Since 2001, constructive policies toward renewable energies started to emerge, for example the tax reduction for the renewable generation industry. From 2009, the government has run several programmes to promote the development of new energy, including renewable energy and nuclear power, as a key industry in China [36]. For example, the MOF launched photovoltaic pilot building programme and the low-carbon building model programme in 2009. Apart from the promotion of renewable energies, the recent finance policies involved a wider range of areas, such as forest development, polite low-carbon cities and province, transforming traditional industrial structure and consumption pattern towards low-carbon development.

The government introduced several financial policies to regulate the structure of the energy exploitation and to promote the development of the renewable resources and clean energy. The National Medium-Term and Long-Term Plan for the Development of Science and Technology 2006–2020 set up high priorities for the research and development of renewable energies such as: fuel cell, hydrogen energy, solar energy and wind power which were listed as major areas of high-tech industrialisation.

The government introduced preferential taxing treatment, as well as actively pursued the creation of favourable financial conditions for these strategic areas of development, and provided relevant guidance to financial institutions. Since 2006, the government has established a special fund which was budgeted by the MOF and was used to support research and exploitation of the renewable natural resources. A total of 225 billion RMB has been invested in energy-efficient technology upgrading and promotion during the 11th Five-Year Plan. The government investments towards new and renewable energy between 2005 and 2010 were 173million RMB, more than all other countries [37].

The Chinese Government adopted several finance and tax policies to increase the energy costs of traditional resources and to invest in renewable energies. As China's economy relied heavily on manufacturing, rising energy prices will certainly damage the rapid growing trend of the economy. The government faced a dilemma in low-carbon governance in terms of achieving the right balance between energy shortage and economic growth. Some interviewees expressed their concerns on the long-term effectiveness of the finance policies: “The finance initiatives of government stimulate the development renewable energy industry, however, the bigger challenge is how the booming can last in future”.

4.3. Reforestry

4.3.1. Law and regulations

Reforestry was initially placed in the 10th Five-Year Plan (2000–2005), then reforestry and developing energy forest became important policies in China's low-carbon development. The legislation system regarding forest protection and development experienced a series of changes. The Forest Law of the PRC was firstly issued on 1984, and was amended in 1998. The purpose of the law was to protect, develop and utilise forest resource, promote greenery. More strict punishment means for illegal logging were introduced into the law. The government is in the process of drafting the Nature Reserve Law aiming to protect nature reserve from land development in the rural areas.

Following the Forest Law of the PRC, the State Council published the Regulation for the Implementation of the Forest Law of the PRC in 2000, defining detailed regulation in forest development and protection. In 2003, the State Council issued the Decision on Accelerating Forest Development in order to promote sustainable development.

4.3.2. Industrial standards

In 2004, the State Forestry Administration issued the Notice of the General Office of the State Council on further strengthening the forest fire prevention work, which aimed to protect the existing forest resources.

In order to fight against illegal logging, the State Forestry Administration announced the Provision of the Forest Destruction Accountability System and the Reporting System for Major Cases in 2001, the Management Regulation of the Requisition and Audit Approval of Forest Land Occupation, the Opinion of the Strict Management of Natural Forests and the Notice about Regulating the Tree Excavation Management in 2003 and the Contingency Plans for Major Forestry Ecological Damage Accidents in 2005.

The Resolution of the National People's Congress Standing Committee on Tackling Climate Change (2009) stressed the importance of development of forest resources in combating climate change. Therefore, the State Forestry Administration issued the Action plan of the forestry sector on fighting climate change in 2009, in order to promote afforestation and ecological projects. In the same year, the A Guide on Sustainable Overseas Forests Management and Utilisation by Chinese Enterprises was published in order to regulate the forest industry behaviour.

4.3.3. Finance and taxation

The investment from the central government on forest industry grew rapidly since 2000. The total investment in forest development was around 673 billion from 2000 to 2010, with an average increase of 27% each year [1]. In 2006, the State Forestry Administration announced the Notice of the State Forestry Administration on Forest Carbon Sequestration Several Guidance. The China Green Carbon Fund was established in 2007 by the central government to support forest carbon sink projects, such as the key shelterbelt construction, the forest protection, the return farmland to forest projects.

The interview with the expert in the National Development and Reform Commission (NDRC) revealed that the Chinese Government viewed the importance of reforestry not only as a mean for environmental protection but also for the carbon reduction and carbon trading. Except for the endeavours put inside

China, the Chinese Government proactively helped some neighbour developing countries in reforestry, such as Myanmar, Laos and Cambodia. For example the government encouraged the Chinese enterprisers to develop more sustainable forest industry through the Narcotics Replacement Planting programme. In addition, the Chinese Government has established collaboration with other countries in Asia and Europe against illegal logging.

4.4. Developing circular economy

4.4.1. Law and regulations

The policy to develop circular economy was initially found in the 11th Five-Year Plan. The most recent policies focused on resource recycling system coving all aspects of the society, from production, circulating to consumption. In supporting circular economy, some legal instruments were introduced by the government.

The government issued the Cleaner Production Promotion Law of the PRC (2004) and Law of the PRC the Prevention and Control of Environmental Pollution by Solid Wastes (2004 Revision). Under the two laws, the Renewable Resources Recycling Management Method was announced in 2007. The purpose of the regulation was to promote recycling of renewable resources and more importantly the development of recycling industry.

In 2005, the State Council announced the Opinions on the Accelerating the Development of Circular Economy, aiming for legal supporting system for circular economy, efficiency improvement of resource use and waste recycling. The Circular Economy Promotion Law of the PRC taking effect on January 1, 2009, which took into consideration the close relationship between economic development and environmental problems, strengthened the power of the Renewable Energy Law. The law also initiated many pilot programmes on waste recycling.

Through the recent policy instruments, China has become the top resource recovering country. However, there is still a lack of compulsory regulations for domestic wastes classification and recycling, as most of the waste collection facilities in the urban areas do not classify waste to metal, plastic, paper, electrical devices and so on. In addition, there is only pollution control regulation on landfill in China, but no quantity control regulation. Landfill is still the main means for waste disposal accounting for about 85% of wastes in the urban areas went to landfill [23].

4.4.2. Industrial standards

Unlike the renewable energy industry, where the state-owned companies dominated the market, the government encouraged the private sector to lead the role in circular economy development. In 2007, the first resources recovery management measure was issued by the government, which was the Administration Measure for Renewable Resource Recovery. There is not, however, a formal industry standard for this sector at the moment. The interview survey revealed that the government is currently drafting the industry standard for resource recovery and recycling, which will be the first of this kind.

After several years' development, the waste recycling industry is now a large emerging industry in China under the recent promotion of the government policies.

4.4.3. Finance and taxation

The government also issued regulations to manage the special fund for recycling economy development in the Interim Measures for the Administration of recycling economy development special fund in 2012. The government set up over 190 pilot programmes to promote circular economy in China. A number of cities have been appointed as pilot cities as circular economy development models. It is estimated the waste recycling industry creates annual output value over one trillion RMB and 20 million jobs.

Although the government has lately set up carbon reduction targets, energy saving targets, forestation targets and so on, there were no landfill reduction targets in China.

4.5. Industry restructuring

4.5.1. Law and regulations

The development of third industry was stressed by the government in the State Council's Interim Provisions to Promote Industrial Restructuring in 2005 in order to guide social investment and promote the industrial restructuring. In the State Council's Opinions on Accelerating the Development of the Service Sector in 2007 development targets for service industry were established.

In 2008, the government issued the Opinion on the Implementation of a Number of Policy Measures to Accelerate the Development of the Service Sector and the Guidelines for Accelerating the Development of High-tech Service Industry. New adjustment plans were adopted in order to set up higher standards for those energy consuming manufacturing companies in car, steel, petrochemical industries.

The NDRC carried out price reform on major resources in order to change the heavy industry structure since 2009. The reform policies included water, electricity, and oil price adjustment. The Notice on Perfecting the Policy on the On-Grid Electricity Price of the Electricity Generated by Wind Power (2009) and the Notice on Clean-up Preferential Electrovalence and Related Issues (2009) were adopted to encourage the development of resources with high-quality wind-power industries. The regulations aimed to check up and revoke Preferential Electrovalence measures delivered to those energy-intensive industries.

In 2010, the State Council announced the Decision on Accelerating the Training and Development of Strategic and Emerging Industries, which emphasised the development of the new industry, such as energy saving, environmental friendly technology, biotech, high-end equipment manufacturing, new energy, new material, and new energy car industries. In addition, new tax and financial policies were introduced for the emerging industries regarding to low-carbon economy development. For example, the government set up 20 investment funds to support the innovative enterprises in energy saving, environmental protection, new energy development and other sectors in strategic and emerging industries. The Decision set up a new target to increase the percentage of Strategic and Emerging industry in GDP to 8% until 2015.

4.5.2. Industrial standards

In terms of the industrial standards, the government has raised market entry thresholds for energy intensive industries, enhanced energy saving evolution and technology transformation for traditional industries. During the interview survey, experts believed those backward low energy efficient companies could be eliminated from the market eventually.

4.5.3. Finance and taxation

During the 2008 global financial crisis, the Chinese Government announced 4 trillion RMB economic stimulus plan, 5% of which invested in energy saving and environment improvement and 9% of which was used to optimising the structure for the energy intensive industries [36]. According to China's Policies and Actions on Climate Change (2008) the government established financial subsidies to enhance the energy-saving products.

Table 2
The legal instrument regarding low-carbon governance in China.

ID	Regulations	Related law	Objectives
2000-I	Power Conservation Management Method (2000)	Energy Conservation Law of the PRC (1997, amended in 2007)	To strengthen the administration of energy conservation, to upgrade energy efficiency, to use the electricity rationally, to optimise energy structure, and to keep the economy development uninterrupted
2000-II	Regulation for the Implementation of the Forest Law	Forest Law of the PRC (1984, amended in 1998)	To regulate the implementation of the forest law
2003-I	State Council's Decision on Accelerating Forest Development	Forest Law of the PRC	Accelerating forest development to promote the sustainable social and economy development
2004-I	Measures for Operation and Management of Clean Development Mechanism (2004)	The provisions of the UN Framework Convention on Climate Change and its Kyoto Protocol	To strengthen the effective management of Clean Development Mechanism (CDM) projects by the Chinese Government, to protect China's rights and interests, and to ensure proper operation of CDM project activities
2004-II	Energy-efficiency Label Management Method (2004)	Energy Conservation Law of the PRC Product Quality Law of the PRC	To strengthen administration of energy conservation, to promote energy-saving technologies and to improve energy efficiency
2005-I	Civil Building Energy- saving Management Method (2005)	Energy Conservation Law of the PRC	To support the administration of energy conservation of civil buildings, to increase the energy efficiency, and to improve the quality of indoor thermal environment
2005-II	Interim Provisions to Promote Industrial Restructuring	A number of relevant laws	To strengthen and improve macroeconomic regulation to guide social investment, promote the optimisation and upgrading of industrial structure
2006-I	The Interim Provisions on the Punishment of Violation of Environmental Protection (2006)	Environmental Protection Law of the PRC (1979, amended in 1989)	To strengthen the environmental protection, to punish the violating of environmental protection, and to ensure thorough implementation of the environmental protection laws
2007-I	Renewable Resources Recycling Management Method (2007)	Law of the PRC on Promoting Clean Production (2002, amended in 2012), Law of the PRC on the Prevention and Control of Environmental Pollution by Solid Wastes (2004 Revision)	To promote renewable resources and recycling, to regulate the development of renewable resources recycling industry, to save resources, to protect the environment and to achieve sustainable development
2007-II	National Pollution Sources Census Regulation	Environmental Protection Law of the PRC (1989)	To check out the quality, industries and regional distribution of the pollution sources, to apprehend the origin, emission and treatment of the major pollution, to build the database and environmental statistic platform of the pollution sources for social development and environmental protection
2007-III	The State Council's Opinions on Accelerating the Development of the Service Sector	The Outline of the 11th Five-Year Plan	To speed up the development of the service industry
2008-I	Regulations on Implementation of Corporate Income Law	The Law of the PRC on Enterprise Income Tax (2007)	To regulate the implementation of the Corporate Income Law
2008-II	Civil building Energy-Saving Management Regulation	Energy Conservation Law of the PRC	To reduce energy consumption during the service process of the civil building and to improve the utilisation ratio of the energy in order to strengthen the energy-saving management of the civil building; to reduce the energy-consumption activities in the service process of the civil buildings
2008-III	Directory of Classification Management of Construction Projection of Environmental Impact Assessment (2008)	Law of the PRC on Appraising of Environment Impacts (2002)	To classify the management of construction projects depending on the project's impact on the environment
2008-IV	Energy Conservation Regulation for State-funded Institutions	Energy Conservation Law of the PRC	To promote energy conservation and to improve energy efficiency of public institutions. Let the public institutions play an exemplary role in the energy saving of the whole society
2008-V	Interim Administration Measures for the straw energy utilisation subsidies	Renewable Energy Law of PRC (2005)	To regulate the management and improve the effective use of straw energy utilisation subsidies
2009-I	Planning Environmental Impact Assessment Ordinance (2009)	Law of the PRC on Appraising of Environment Impacts (2002)	To strengthen the assessment of the environmental impact;, to prevent the environmental pollution and ecological destruction from the headstream, to promote the all-round and harmonious sustainable development of the economy, society and environment.
2009-II	Road Transport Vehicle Fuel Consumption Monitoring and Supervision and Management Method (2009)	Energy Conservation Law of the PRC (2007), and Road Transport Regulation of the PRC	To enhance the administration of energy conservation of the road transport vehicles
2009-III	High Energy-consuming Special Equipment Supervision and Management Measures (2009)	Energy Conservation Law of the PRC (2007)	To give special supervision requirement for high-energy-consuming special equipment, upgrade the energy efficiency, promote resource utilisation efficiency.
2009-IV	Administration Measures of the Standardisation in Energy Sector	Standardisation Law of the PRC (1988)	To regulate administration of the standardisation in the energy sector
2010-I	Interim Measures of Supervision and Management of Central Enterprise Energy Saving (2010)	Energy Conservation Law of the PRC Environmental Protection Law of the PRC	To urge the implementation of social responsibility on energy conservation, to build resource-saving and

Table 2 (*continued*)

ID	Regulations	Related law	Objectives
			environmentally friendly enterprises, to accelerate the transformation of mode of economic development
2011-I	Standard Construction Regulation for Wind Power (2011)	The Standardisation Law of the PRC	To establish national standard system for the wind power industry, and to well manage the construction of wind power industry
2011-II	Interim Administration Measures for the collection and use of the renewable energy development fund	Renewable Energy Law of PRC (2005)	To promote the exploitation and use of renewable energy
2011-III	Interim Administration Measures for the Green Energy Demonstration Counties Subsidies	Renewable Energy Law of PRC (2005)	To promote the renewable energy development in countryside, optimise energy consumption structure, promote clean production, and improve living standard of farmers
2012-I	Interim Measures for the Administration of recycling economy development special fund	Circular Economy Promotion Law of the PRC (2008) and Budget Law of the PRC (1995)	To regulate the initiative fund for circular economy development and improve the effective use of finances

5. Discussions

The low-carbon development became an increasingly important strategy for China, while the central government gradually introduced various policy instruments to support its low-carbon governance. The policy instruments were gradually introduced from environmental protection, energy conservation, development of new and renewable energy, to the development of circular economy, industry restructuring which constructed today's policy instruments to support the low-carbon economy development.

The legal system regarding low-carbon development experienced enormous changes in the last decade. These were series of laws and regulations providing the legal instruments to achieve the low-carbon development strategy of the Chinese Government. These recently published laws formed guiding principle and accountability in the legal system. Various government departments within the central government issued supporting regulations and measures in order to build a strict energy saving administration system and strengthen the incentive measures. The relevant regulations and laws are listed below in Table 2.

New industrial standards were introduced to support those laws and regulations. However, some of the energy conservation standards were found less strict than some other countries. Some industry standards are missing such as the standard for resource recovery industry. The new green label and market entry standards helped regulating the market and constraining enterprises.

Almost all policies were supported by tax incentive and financing assistants from the central government such as pilot project, pilot low-carbon city and province. However, the government did not clearly define the criteria for low-carbon city and province [12]. Development of new energy and renewable energies occupied full attention from almost all government departments.

Currently the solar and hydro-electricity industries in China both are the largest ones in the world in terms of annual electricity production. In 2010, the energy consumption per unit of GDP in China dropped 19.1% from that of 2005.

Waste landfill is also a major source of green house gas emissions in China, and further more efforts should be made in this field. Regulations are required to control the quantity of landfill and encourage the implement of new technologies for waste assorting and disposal. In addition, the landfill reduction targets should be included in the performance assessment criteria for the local governors.

For better implement of the policy instrument, the government made organisational adjustment. In 2007 the government established the National Leading Group to Address Climate Change in 2007 assigning specific works to the NDRC. Another new organisation – the National Energy Commission was established in 2010. As a national level organisation, the commission in charge of the strategic decision-making on energy structure, policy, price and international collaboration of the nation. Furthermore, local energy sub-commissions were also established at the provincial levels. The head of the new organisations was the Prime Minister Wen Jiabao and the members were the heads of various government departments. Furthermore, local energy sub-commissions were also established at the provincial levels. The structure of the organisation benefits the strategic decision-making, the coordination between various departments, and the prompt corresponds from the local governments in different regions.

The establishment of the new organisations by the central government also initiated relevant new institutes in multiple levels, for example the climate change department by NDRC, the climate change offices at local level, and various research institutes by government departments. These institutes together with existing energy conservation and new energy institutes organisationally formed a managerial structure for low-carbon governance.

The establishment of the new organisations by the central government also initiated relevant new institutes in multiple levels, for example the climate change department by NDRC, the climate change offices at the local level, and various research institutes by government departments. These institutes together with existing energy conservation and new energy institutes organisationally formed a managerial structure for low-carbon governance, which could potentially benefit the implementation of various policy instrument.

6. Conclusions and recommendations

The development of policy instruments that support low-carbon governance in China was reviewed in various aspects including: energy conservation, development of new energy, development of circular economy, reforestry, and industry restructuring. According to the research, there are several areas facing possible improvement for the low-carbon policy instruments for low-carbon governance.

Some suggestions for establishing good low-carbon governance in China are given below, which mostly concentrate on the operational rather than the strategic level.

1. Law enforcement for the new established laws should be further strengthened and stricter supervision systems should be in place to safeguard effective implementation of low carbon

policies, measures and standards, especially for those energy condensed sectors.

2. More rigorous industry standards should be considered to help eliminate outdated equipments in industries and promote the introduction of more climate-friendly technologies.
3. The industrial standards should be given strong legal support in accountability, in order to enforce their complete application once in operation. New assessment tools need to be introduced to measure the effects of the implementation of the industrial standards in real projects.
4. More attention should be paid to landfill issue by the government in the future. New policies and instruments need to be introduced in order to reduce carbon print by landfill.
5. In order to encourage the fast development of new technologies, the backward law and industrial standards in China should be upgraded more regularly, therefore, to support the low carbon development strategy.

This research is not exhaustive in nature. As there are not adequate data available, it is hard to assess the effects of the most recent policy instruments of the Chinese governance. It is necessary for researchers to investigate the consequences of the low-carbon policy instrument in the future. Future research should review the achievements of the low-carbon policies in practice, such as the long-term plan of the Chinese Government, in order to evaluate the effectiveness of the low-carbon governance in China.

Acknowledgement

The authors would like to express their gratitude to experts at NDRC for their collaboration during interview survey. This research is sponsored by Natural Science Foundation of Shandong (Grant no. ZR2013GQ014) and Independent Innovation Foundation of Shandong University (Grant no. IFW12108 and IFW12065).

References

[1] National Bureau of Statistics of China. China yearbook 2012. Beijing: China Statistics Press; 2013 [in Chinese].
[2] UNDP. China and a sustainable future: towards a low carbon economy and society. China human development report 2009/10. Compiled by United Nations Development Program. Beijing: China Translation and Publishing Corporation; 2010.
[3] Chen W. The costs of mitigating carbon emissions in China: findings from China MARKAL-MACRO modeling. Energy Policy 2005;33(7):885–96 (CIA, 2008. The world factbook).
[4] Cai W, Wang C. Comparison of CO_2 emission scenarios and mitigation opportunities in China's five sectors in 2020. Energy Policy 2008;36(3):1181–94.
[5] Wang T, Watson J. Scenario analysis of China's emissions pathways in the 21st century for low carbon transition. Energy Policy 2010;38(2010):3537–46.
[6] Wang R, Liu W, Xiao L, Liu J, Kao W. Path towards achieving of China's 2020 carbon emission reduction target—a discussion of low-carbon energy policies at province level. Energy Policy 2011;39(5):2740–7.
[7] Chang Y, Wang N. Emission trading control and environmental regulations in China. J Energy Policy 2010;38(7):3356–64.
[8] Li J. The government management innovation towards low carbon economy. Leadership Sci 2010;2010(10):4–6.
[9] Foxon T. A coevolutionary framework for analysing a transition to a sustainable low carbon economy. Ecol Econ 2011;70(12):2258–67.
[10] Luchsinger G. China human development report 2009/10, China and a sustainable future: towards a low carbon economy and society. China Translation and Publishing Corporation; 2010.
[11] McEvoy D, Gibbs DC, Longhurst JWS. The employment implications of a low-carbon economy. Sustain Dev 2000;8(1):27–38.
[12] Price L, Zhou N, Fridley D, Ohshita S, Lu H, Zheng N, et al. Development of a low-carbon indicator system for China. Habitat Int 2013;37(1):4–21.
[13] Wang N, Chang Y, Ding R. The path towards low-carbon governance for China [C]. In: IEEE proceedings of the 1st international technology management conference (ITMC 2011). Califonia, USA: EI, ISTP; 2011. p. 547–50.
[14] Zhou N, Levinea MD, Price L. Overview of current energy-efficiency policies in China. Energy Policy 2010;38(11):6439–52.
[15] Lo K. A critical review of China's rapidly developing renewable energy and energy efficiency policies. Renew Sustain Energy Rev 2014;29:508–16.
[16] Li H, Bao W, Xiu C, Zhang Y, Xu H. Energy conservation and circular economy in China's process industries. Energy 2010;35(11):4273–81.
[17] Zeng M, Liu X, Li N, Xue S. Overall review of renewable energy tariff policy in China: evolution, implementation, problems and countermeasures. Renew Sustain Energy Rev 2013;25:260–71.
[18] Zhang S, He Y. Analysis on the development and policy of solar PV power in China. Renew Sustain Energy Rev 2013;21:393–401.
[19] Jiang B, Sun Z, Liu M. China's energy development strategy under the low-carbon economy. Energy 2010;35(2010):4257–64.
[20] Yuan C, Liu S, Fang Z, Wu J. Research on the energy-saving effect of energy policies in China: 1982–2006. Energy Policy 2009;37(2009):2475–80.
[21] Wang N, Chang Y, Dauber F. Carbon print comparison of buildings in UK and China under the new energy conservation regulations. J Energy Build 2010;42:95–698pp6 2010;42:95–698.
[22] Andrews-Speed P. China's ongoing energy efficiency drive: origins, progress and prospects. Energy Policy 2009;37(2009):1331–44.
[23] Sun Y, Li M. The problem and strategy in waste landfill. China Sci Technol Inf 2011;2011(18):39.
[24] Chai Q, Zhang X. Technologies and policies for the transition to a sustainable energy system in China. Energy 2010;35(2010):3995–4002.
[25] Huang L, Liu J, Shao Q, Xu X. Carbon sequestration by forestation across China: past, present, and future. Renew Sustain Energy Rev 2012;16(2012):1291–9.
[26] Fang Y, Zeng Y. Balancing energy and environment: the effect and perspective of management instruments in China. Energy 2007;32(2007):2247–61.
[27] Ma L, Liu P, Fu F, Li Z, Ni W. Integrated energy strategy for the sustainable development of China. Energy 2011;36(2011):1143–54.
[28] Zhang J, Deng S, Shen F, Yangh X, Liu G, Guo H, et al. Modelling the relationship between energy consumption and economy development in China. Energy 2011;36(2011):4227–34.
[29] Zhang Z. Is it fair to treat China as a Christmas tree to hang everybody's complaints? Putting its own energy saving into perspective Energy Econ 2010;32:S47–56.
[30] Berg S. Sustainable regulatory systems: laws, resources, and values. Util Policy 2000(2000):159–70.
[31] Yoshino H, Yoshino Y, Zhang Q, Mochidad A, Li N, Li Z, et al. Indoor thermal environment and energy saving for urban residential buildings in China. Energy Build 2006;38(November (11)):1308–19.
[32] Li J. Build green buildings for sustainable development of construction industry. China High Tech Enterprises 2010;157(22):10–1.
[33] CEIN. Public buildings consume half residential electricity; 2007 ⟨www.cein.gov.cn⟩.
[34] SPIN. Forecasting electricity prices in the 11th five-year period. State Power Information Network; 2007 ⟨www.sp.com.cn⟩.
[35] Chang Y, Wang N. An overview of China's environmental governance problems. J Cambridge Stud 2008;1(3):pp43–6.
[36] National Development and Reform Commission. China's policies and actions on climate change 2011; 2011 [in Chinese].
[37] Qi Y. Bluebook of low-carbon development: annual review of low-carbon development in China (2011–2012). Beijing: Social Science Academic Press; 2012 (in Chinese).